

Attachment 6: Monitoring, Assessment, and Performance Measures

The project includes an innovative and robust monitoring and performance assessment program, which will be used to measure performance of this project and can also be exported elsewhere in the Sierra headwaters to measure impact of green infrastructure projects. In addition, our monitoring and performance plan is designed to measure the impact of education and outreach activities for a range of audiences (including IRWMPs across the Sierra), and coordination efforts throughout the state to promote early learning and replication. The specifics of the monitoring system and a performance measures table are provided below.

Quantifies Benefits and Objectives. The monitoring and assessment component of this project is critical to quantifying the benefits of this demonstration project, including reducing flood risk and flood damages through the capture and treatment of stormwater runoff. More specifically, the monitoring and performance plan will be used to verify project performance with respect to the project benefits and objectives. In the performance measure table below we demonstrate how the project objectives are linked to both output and outcome performance measures.

Consistent with the Basin Plan for the Sacramento and San Joaquin Rivers (Basin Plan). This project is consistent with the Basin Plan in the following ways. First, the Basin Plan maintains that: “Runoff from residential and industrial areas also contributes to water quality degradation. Urban storm water runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics, and nutrients. Because these pollutants accumulate during the dry summer months, the first major autumn storm can flush a highly concentrated load to receiving waters and catch basins. Impacts of storm water contaminants on surface and ground waters are an important concern.” (Chapter III). We concur with that statement and our project is designed to specifically address pollutant loads associated with these “first flush” runoff events. In addition, our project is designed to help meet the water quality objectives outlined in Chapter III of the Plan, including those for DO, bacteria, mercury, oil and grease, zinc, copper, lead, arsenic, and turbidity. Lastly, this project meets several of the State Water Board water quality control policies and actions outlined in the Basin Plan (Chapter IV), including the following:

- *State Water Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California.* The policy generally restricts the Regional Water Board and dischargers from reducing the water quality of surface or ground waters. The goal of the policy and our project is to maintain high quality waters.
- *14. Nonpoint Source Management Plan.* In 1988, the State Water Board adopted (Resolution 88-123) a Nonpoint Source Management Plan. The Plan describes three general management approaches that are to be used to address nonpoint source problems. These are: 1) voluntary implementation of best management practices, 2) regulatory based encouragement of best management practices and 3) adopted effluent limits. This project is aimed at promoting voluntary management approaches to address stormwater runoff.

- *6. Storm Water Regulations.* The 1987 Clean Water Act amendments required the USEPA to establish regulations to control storm water discharges associated with industrial activity; discharges from large and medium municipal separate storm sewer systems; and discharges from construction sites. The State Water Board adopted a statewide general NPDES permit in 1992, which applies to construction projects resulting in land disturbance of five acres or greater. This project demonstrates innovative stormwater management practices related to construction activities.

Measures Performance in Meeting IRWMP Goals and Objectives. This project addresses three of the CABY IRWMP's goals and six objectives, largely focusing on the reduction of sedimentation and contamination in waterways of the region through activities such as stormwater management. The CABY goals and objectives do not have specific targets associated with them, thus, we will not be able to gage the specific contribution of this project to the attaining CABY IRWMP goals. The monitoring activities of this project, however, will help us to determine the benefits achieved, thereby allowing us to measure the project's performance in contributing to the applicable CABY IRWMP goals and objectives. In the table below, we list the CABY IRWMP goals and objectives to which this project applies and the associated performance measures that will be used to track its contribution to the CABY goals and objectives.

CABY Goals and Objectives	Performance Measure(s)
Goal 4: Protect infrastructure, equipment, and property from flooding	Reduction of peak runoff rate
Goal 5: Protect and improve watershed resources through land use practices	Green infrastructure facilities capture 5.9 million gallons of stormwater annually
Goal 8: Reduce contamination of surface and groundwater resources	First flush grab surface water samples show reduced levels of pollutants
Objective 2: Implement measures to manage and reduce erosion and sedimentation	Total suspended dissolved solids and turbidity
Objective 9: Implement measures to manage and reduce contamination of waterways	Water quality measures of inflow and outflow
Objective 14: Optimize efficient use, conservation, and recycling of water resources	Groundwater levels
Objective 18: Minimize impervious surface cover and improve infiltration	Green infrastructure facilities capture 5.9 million gallons of stormwater annually
Objective 19: Promote community and regional storm water management plans	Number of brochures distributed Number of articles in press Attendance at Demonstration Days
Objective 22: Evaluate and minimize negative flood impacts on water infrastructure and water	Peak runoff rate

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Monitoring Plan. The following are the overall objectives for the Monitoring Plan for this project:

1. Monitor reductions in the volume of stormwater runoff from the site to receiving waters as a result of the green infrastructure features (rain gardens, vegetated swales, permeable pavement, and retention ponds). Monitor the volume of stormwater runoff entering each feature during storm events using a data logging rain gauge installed at the site along with calculated impervious surface catchment areas.
2. Monitor increases in stormwater runoff retention time through observations of the timing of initial runoff into the green infrastructure features and the timing of initial discharge from the features (if any).
3. Monitor reductions in sediment load by green infrastructure features through observations and measurement of direct catchment, and comparisons of suspended sediment levels in inflow and outflow samples.
4. Evaluate reductions in pollutant load by green infrastructure features through monitoring of absorption (infiltration of runoff) and assumed subsurface attenuation and reductions in discharged pollutant concentrations, as well as comparison of pollutant levels water samples entering and exiting features.
5. Evaluate reduction to flood-related damages and other benefits in the Yuba Watershed if such green infrastructure projects were implemented in a significant portion of the watershed using a modeling approach.

Monitoring Activities. In order to measure performance of our objectives, American Rivers and the South Yuba River Citizens League (SYRCL) will implement a Monitoring Plan to quantify the reduction in stormwater runoff, the decrease in pollution loads, and the decrease in flood damage. Although the California State Water Resources Control Board (SWRCB) has not yet set guidelines for measuring the efficacy of green infrastructure features, an initial Monitoring Plan has been developed with their close cooperation and input from the SWRCB. The Water Monitoring Quality Assurance Project Plan (QAPP) that was completed for Phase I of this project will be amended and submitted for approval to DWR.

The performance of the features will be measured at all the green infrastructure features that have been installed at both public sites using both natural storm events and simulated events described above. The use of simulated events is an innovative approach to monitoring that we will be testing as part of this project. It is our expectation that simulation will prove to be a cost-effective and robust means to measure impact. For the simulated rainfall events, known volumes of water are discharged into the features.

The project will purchase and install automated tipping bucket rain gauges equipped with data loggers. Data from the rain gauges will be correlated with monitoring events and used in evaluation of the green infrastructure feature performance. For example, low to moderate rainfall events are

expected to have no outflow from the features (100% runoff attenuation) and the rain gauge will enable quantification of this primary benefit. In addition the rain gauge will facilitate coordination and timing of stormwater sampling.

Three types of stormwater monitoring activities will be performed during the course of the project. These will include: 1) storm event monitoring, 2) simulated storm event monitoring, and 3) first flush monitoring. The purpose and general scope of each type of monitoring is described below:

1. **Storm Event Monitoring** will be performed in order to monitor the capacity of the green infrastructure features to collect and infiltrate stormwater runoff under different rainfall and soil moisture conditions and to document associated reductions in sediment and pollutant load. Storm event monitoring will be conducted just after construction of the features and will involve observing and documenting rainfall events and visually observing the performance of the features.
2. **Simulated Rainfall Event Monitoring** will be performed after installation of the features and establishment of vegetation. This test will calibrate the amount of rainfall needed to fill each feature. Data from the simulated events will be used for comparison with data from actual rainfall events and will correlate actual data with estimated catchment areas and infiltration coefficients of impermeable surfaces. To simulate a high intensity rainfall, a fire hose equipped with a flow meter will be used to flood the features with a measured amount of water to capacity. Simulations will be performed at two different known soil moisture levels, including one test in late summer or fall (relatively low moisture) and one during mid-winter (relatively high moisture). For each soil state, the amount of rainfall needed to fill each feature will be measured and soil infiltration rates will be quantified. These controlled measurements will be used to calibrate natural rainfall events and enable calculation of the actual runoff volumes treated by the green infrastructure features. These actual treated runoff volumes will then be compared with those we anticipated for each feature of the project to determine performance. During the simulated event, grab surface water samples will be obtained from first inflowing water and first discharge (or bypass) water. Samples will be tested in the field for basic water quality parameters and in the laboratory for total suspended solids (TSS) and turbidity. Samples will be stored under refrigeration and may be analyzed at a later date for selected pollutants and nutrients.

Infiltration rates will be monitored in each feature during simulated events and storm events by observing rates of decreases in standing water within features after runoff inflow has ceased.

3. **First Flush Monitoring** will be performed during the first significant rainfall event after the installation of the features. The purpose of first flush sampling will be to assess the seasonal maximum pollutant concentrations and sediment loads in stormwater flowing into the features and in the first runoff flowing from the feature discharge or bypass. If no discharge

results from the initial first flush storm event, the inflow sample from this event would be analyzed for comparison with the first outflow, which may be collected during a subsequent storm event. First flush grab surface water samples will be analyzed for standard water quality parameters, TDS, turbidity, total dissolved solids (TDS) Total Oil and Grease, nutrients (nitrogen as nitrate and dissolved orthophosphate) and RCRA metals (mercury, copper, zinc, lead, arsenic), total coliform and E. coli.

Water Quality Data Collection and Analysis. In addition, once the feature has filled and water begins to flow through, water quality in the inflow and outflow streams will be measured to determine the flow-through treatment levels for each feature. The following water quality parameters will be monitored during each stormwater-monitoring event using field instruments: Temperature, pH, Conductivity and Dissolved Oxygen. Turbidity analysis will be performed in the office. Stormwater samples will be sent to Cranmer Analytical Laboratory for testing of total suspended solids (TSS). Based on recent conversations with SWRCB staff, suspended solid concentration (SSC) analysis may be used instead of TSS if feasible. First flush samples will be monitored for field parameters, turbidity and TSS. Additional laboratory analyses will include total dissolved solids (TDS), Total oil and grease (TOG), RCRA Metals (mercury, copper, chromium, lead, nickel and zinc), selected nutrients (nitrate as nitrogen and dissolved orthophosphates), e-coli and total coli form. The updated QAPP will be submitted to DWR following SWAMP guidance protocols and this plan will include specific laboratory methods and laboratory reporting limits for these analytes.

First flush feature inflow samples will be analyzed for all the constituents listed above. Outflow samples will be held under refrigeration and later analyzed for selected constituents based on a review of inflow sample results. For example, outflow samples may not be analyzed for constituents not detected in inflow samples or detected at relatively low concentrations based on a literature review of typical stormwater runoff characterization data. Samples obtained during the simulated rainfall event monitoring from inflow and outflow will be monitored for field parameters, turbidity and TSS. Samples will also be held under refrigeration and later analyzed for selected constituents based on a review of first flush sample results.

Data Evaluation and Reporting. Upon completion of the monitoring period, data from the monitoring activities will be evaluated to assess project performance. Calculations will be performed and a project evaluation report will be prepared to address each of the six established monitoring objectives.

1. Volume of stormwater runoff entering each BMP feature will be calculated for specific stormwater monitoring events and calculations of runoff coefficients for catchment areas will be performed based on data recorded from the on-site rain gauge, BMP feature construction details, hydrological calculations and data collected during specific storm event and simulated rainfall event monitoring. Reductions in volume of stormwater runoff entering receiving waters will be calculated for specific events and seasonal estimates will be made based on specific storm event monitoring and simulated rainfall event monitoring data.

2. Stormwater runoff retention time within BMP features will be calculated based on field observations of initial inflow and outflow times during stormwater monitoring events, which represent the delayed timing of inflow to receiving waters. Infiltration rates will be calculated based on observations of water level reduction rates within the BMP features after inflow has ceased during the simulated rainfall monitoring events and during the later part of stormwater monitoring events.
3. Reductions in sediment load entering receiving waters through deposition within the BMP features will be calculated based on turbidity and TSS analysis of inflow samples which are completely infiltrated and when discharge occurs, through comparison of inflow and outflow turbidity and sediment concentrations.
4. Reductions in pollutant load entering receiving waters through infiltration and treatment within the BMP features and underlying soil will be calculated based on sample analysis of pollutant concentrations in inflow samples which represent 100% infiltrated runoff and, when discharge occurs, through comparison of inflow and outflow pollutant concentrations.
5. Reductions in flood-related damages and other benefits in the Yuba Watershed will be calculated assuming green infrastructure approaches were established to treat 50% of the projected increase in runoff due to development in the watershed over the next five years. By reducing the volume of stormwater runoff, green infrastructure can reduce the frequency and severity of flooding.

There are several ways to address the value of reduced flood risk provided by green infrastructure practices on a watershed-scale. We will follow a method used in the Blackberry Creek Watershed in Kane County, Illinois (Johnston, Braden and Price 2006) where the authors used *EPA's Hydrologic Simulation Program* to model the difference in peak flows of a green infrastructure versus a conventional development scenario. They then input their peak flow results into the Army Corps of Engineers' Hydrologic Engineering Center River Analysis System and found that conventional development would add 50 acres to the floodplain compared to development using green infrastructure for stormwater management. Applying an anticipated density of 2.2 units/acre and the census bureau's reported median home value of \$175,600, the study then used the benefits transfer approach to estimate a range of values for flood risk reduction. Using a range of 2-5 percent property value increase for removal from the floodplain yields total benefits of between \$391,600 and \$979,000 for the flood risk reduction of the green infrastructure scenario.¹ We will pursue a similar approach to measuring benefits of reduced flood risk for this project.

¹ The most robust literature on the economic valuation of flood risk uses hedonic pricing methods to investigate the housing price discount associated with floodplain location. Most of these studies estimate the impact on residential home prices of locations inside or outside the 100-year floodplain.

Performance Measures Table

Project Objectives	Desired Outcomes	Output Indicators	Outcome Indicators	Measurement Tools & Methods	Targets
<p>Protect water quality through the capture and infiltration of 100 percent of “first flush” runoff, which normally contains the highest pollutant concentrations</p> <p>Protect water quality through the capture and infiltration of 100 percent of runoff in approximately 90 percent of storm events</p>	<p>1) Green infrastructure facilities capture and infiltrate 100% of “first flush” runoff</p> <p>2) Bio-swales capture all runoff in $\geq 50\%$ of all storms; pollutant loads in overflow are substantially reduced</p> <p>3) Rain garden captures all runoff in $\geq 90\%$ of all storms; pollutant loads in overflow are substantially reduced</p>	<p>1) Finalized Facility Conceptual and Technical Plans</p> <p>2) On-Site photographs and videos of before and after construction</p> <p>3) Monitoring report</p>	<p>First flush grab surface water samples analyzed for standard water quality parameters, TDS, turbidity, total dissolved solids (TDS) Total Oil and Grease, nutrients (nitrogen as nitrate and dissolved orthophosphate) and RCRA metals (mercury, copper, zinc, lead, arsenic), total coliform and E. coli.</p> <p>Water quality</p>	<p>Water Monitoring Plan developed in consultation with the State Water Resources Control Board and consistent with QAPP for monitoring in water quality in the Yuba watershed. This Plan will be updated to include the YRCS site and approved by DWR.</p> <p>Samples will be tested in the field for basic water quality parameters and in the laboratory for total suspended solids and turbidity. Samples will be stored under refrigeration and analyzed for selected pollutants and</p>	<p>$\geq 50\%$ of storms captured by bio-swale and $\geq 90\%$ of storms captured by rain garden</p> <p>95% reduction in total stormwater runoff from treated areas over full season</p> <p>99% reduction in pollutant loads (see monitoring plan) from treated parking lot area</p>

			measurements of inflow and outflow (if overflow occurs), including: total suspended and dissolved solids; turbidity; nitrogen (as dissolved orthophosphate) ; total coliform and E. coli; hydrocarbons (oil and grease)	nutrients. Reduction in sediment load determined through comparison of suspended sediment levels in inflow and outflow samples	
Educate local landowners, county officials, community members, and adjacent IRWMPs about the need for green, low-impact stormwater treatment Promote replication of green	1) Broad attendance at Demonstration Days, including Nevada City officials and members of the press 2) Interpretive station is well accepted, and publicized 3) Brochure is used by other	1) Finalized sign design 2) Finalized brochure design 3) Photographs of in place signage 4) Copies of Press coverage	1) Number of brochures distributed in the first month 2) Attendance at Demonstration Day 3) Number of articles in the press	Counts of indicators	150 people attend demonstration day At least 4 media articles cover rain garden 100 brochures distributed in first month

infrastructure stormwater management facilities in the Sierra headwaters through education and outreach Quantify and communicate project benefits through innovative monitoring and demonstration activities	municipalities and IRWMPs in the Sierra Nevada to provide information about the benefits of green infrastructure				
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